SECOND-GENERATION PFBC Systems R&D

Phase 2 and Phase 3
MONTHLY REPORT

Period Start Date 01/01/2000 End Date 01/31/2000

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TECHNICAL PROGRESS REPORT NUMBER 21023R52
FOR MONTH 142 (JANUARY 2000) -- PHASE 2

No work was performed; the two remaining Multi Annular Swirl Burner test campaigns are on hold pending selection of a new test facility (replacement for the shut down UTSI burner test facility) and identification of associated testing costs.

TECHNICAL PROGRESS REPORT NUMBER 21023R53
FOR MONTH 111 (JANUARY 2000) -- PHASE 3

Commercial Plant Design Update

Introduction

The Second-Generation PFB Combustion Plant conceptual design prepared in 1987 is being updated to reflect the benefit of pilot plant test data and the latest advances in gas turbine technology. The updated plant is being designed to operate with 95 percent sulfur capture and a single Siemens Westinghouse (SW) 501G gas turbine. Using carbonizer and gas turbine data generated by Foster Wheeler (FW) and SW respectively, Parsons Energy and Chemicals Group prepared preliminary plant heat and materials based on carbonizer operating temperatures of 1700 and 1800EF and found the former to yield the higher plant efficiency.

As a result, 1700EF has been selected as the preferred operating condition for the carbonizer. The previous first cut plant heat and material balance was refined and it predicts a 47.7% plant efficiency (HHV) with a net power output of 421.1 MWe. The latter includes a plant auxiliary load estimated to be 23.5 MWe or 5.26% of the gross plant power and a transformer loss of 1.5 MWe. Coal drying is through natural gas combustion, and the thermal energy input of the natural gas has also been included in the heat rate calculation. Figure 1 presents the plant preliminary full load heat and material balance. In this arrangement, evaporation and primary steam superheating tube surfaces are placed in both the pressurized circulating fluidized bed boiler (PCFB) and the gas turbine heat recovery steam generator (HRSG). The superheated steam from these units is mixed and then heated to 1050EF in the PCFB finishing superheater. With regard to steam reheating, the primary stage is located at the front of the HRSG and the final stage is located in the PCFB.

Keeping the gas turbine at 15 percent load to avoid switching from steam to air cooling, a heat and material balance was prepared that indicates a net plant output of 97 MWe at a nominal load of 25 percent. The balance presented in Fig. 2 shows gas turbine and steam turbine outputs of 35.9 and 79.7 MWe or 15 and 39 percent of full load respectively. At this condition the gas turbine inlet guide vanes are closed (air flow is reduced by 27 percent) and the gas turbine exhaust temperature is reduced from 1138EF down to 741EF. The steam turbine has been set for fixed pressure operation, and with the main steam flow reduced to 4,552,800 lb/h (40 percent of full load) superheat and reheat temperatures are shown as being maintained at 1050EF with carbonizer syngas and PCFB flue gas volumetric flow rates at 12 and 127 percent of full load values.

Work Performed in January 2000

During this report period Parsons completed two additional part load heat and material balances of the dry-fed, 1,700EF carbonizer case. These two cases, Figures 3 and 4 respectively, corresponded to 70 percent and 50 percent of design load.

The 70 percent part load condition was achieved by running the 501G gas turbine at 65 percent of its design load and the steam turbine at 72 percent of its design load. At this condition, the gas turbine firing temperature is essentially unchanged but the inlet guide

vanes have been closed, thereby reducing the air flow by about 27 percent. Net system efficiency for this part load condition is estimated at 46 percent HHV.

The 50 percent part load condition was achieved by running the 501G gas turbine at 45 percent of its design load and the steam turbine at 55.6 percent of its design load. With the gas turbine inlet guide vanes having been previously closed, the gas turbine firing temperature has been reduced for further load reduction. Net system efficiency for this part load condition is estimated at 45 percent HHV. For this case, additional "fresh" coal flow was added to the PCFB to augment carbonizer char flow and maintain the PCFB at 1600EF.

As the reporting period ended, the 50 and 75 percent load balances were being forwarded to FW for review, and preliminary carbonizer sizing calculations for 100% load were completed.

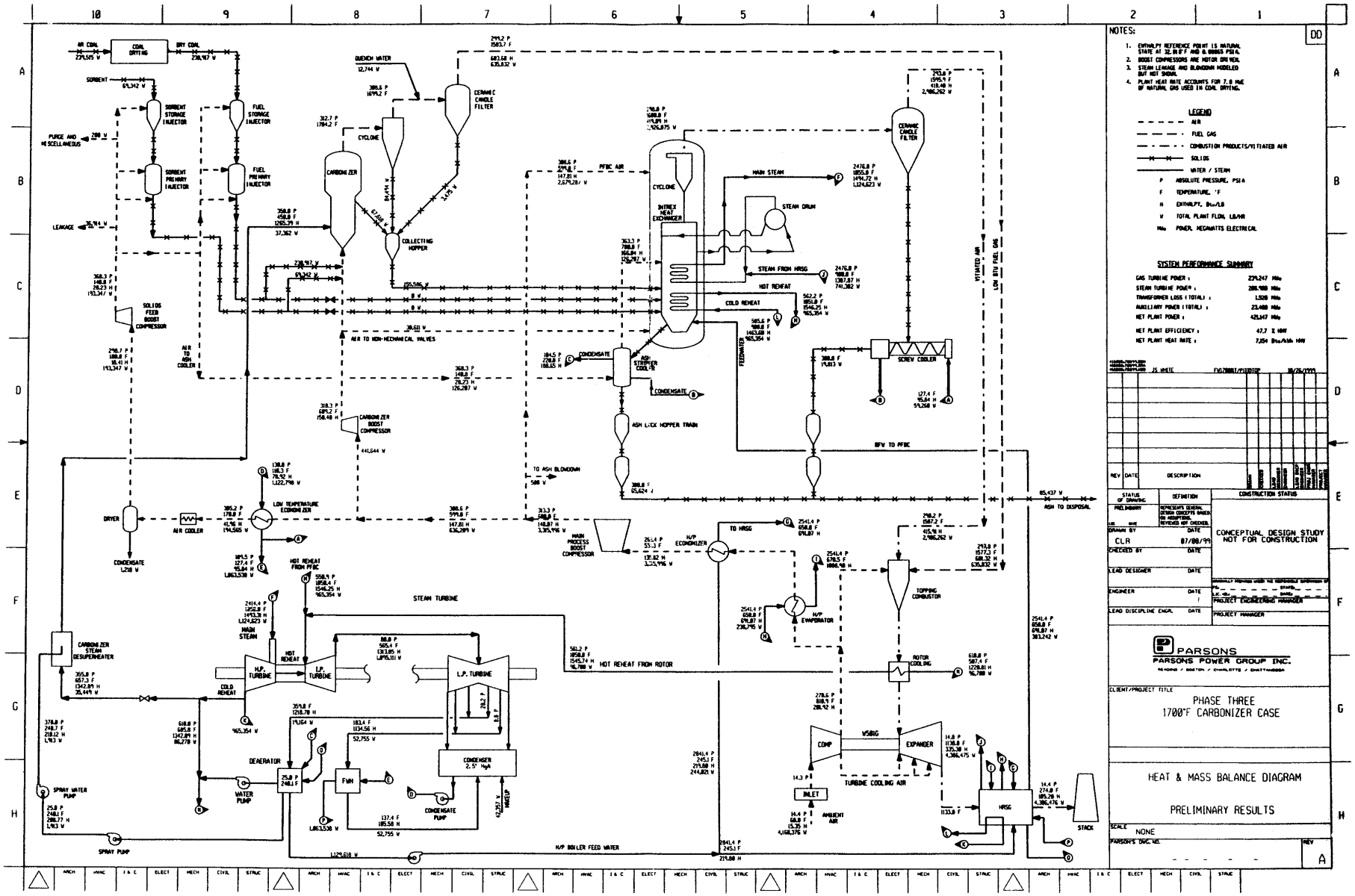
NOTES:
1. ENTHALPY REFERENCE POINT IS NATURAL STATE AT 32.018°F AND 0.08865 PSIA.
2. BOOST COMPRESSORS ARE MOTOR DRIVEN.
3. STEAM LEAKAGE AND BLOWDOWN MODELED BUT NOT SHOWN.
4. PLANT HEAT RATE ACCOUNTS FOR 7.8 MWe OF NATURAL GAS USED IN COAL DRYING.
LEGEND
AIR
FUEL GAS
COMBUSTION PRODUCTS/VITIATED AIR
SOLIDS
WATER / STEAM
P ABSOLUTE PRESSURE, PSIA
T TEMPERATURE, °F
H ENTHALPY, Btu/LB
W TOTAL PLANT FLOW, LB/HR
MWe POWER, MEGAWATTS ELECTRICAL
SYSTEM PERFORMANCE SUMMARY
GAS TURBINE POWER : 239,247 MWe
STEAM TURBINE POWER : 285,188 MWe
TRANSFORMER LOSS (TOTAL) : 1,528 MWe
AUXILIARY POWER (TOTAL) : 23,488 MWe
NET PLANT POWER : 423,147 MWe
NET PLANT EFFICIENCY : 47.7 % HHV
NET PLANT HEAT RATE : 7,154 Btu/kWh HHV
PARSONS
PARSONS POWER GROUP INC.
CLIENT/PROJECT TITLE
PHASE THREE
1700°F CARBONIZER CASE
HEAT & MASS BALANCE DIAGRAM
PRELIMINARY RESULTS
CONCEPTUAL DESIGN STUDY NOT FOR CONSTRUCTION
SCALE NONE
REV A
COAL DRYING
QUENCH WATER
CERAMIC CANDLE FILTER
CYCLONE
CARBONIZER
COLLECTING HOPPER
PFBC AIR
INTREX HEAT EXCHANGER
STEAM DRUM
MAIN STEAM
HOT REHEAT
COLD REHEAT
STEAM FROM HRSG
SCREW COOLER
ASH LOCK HOPPER TRAIN
VITIATED AIR
LOW BTU FUEL GAS
BFW TO PFBC
TO ASH BLOWDOWN
ASH TO DISPOSAL
SOLIDS FEED BOOST COMPRESSOR
AIR TO ASH COOLER
CARBONIZER BOOST COMPRESSOR
MAIN PROCESS BOOST COMPRESSOR
LOW TEMPERATURE ECONOMIZER
H/P ECONOMIZER
TO HRSG
TOPPING COMBUSTOR
H/P EVAPORATOR
ROTOR COOLING
STEAM TURBINE
H.P. TURBINE
I.P. TURBINE
L.P. TURBINE
HOT REHEAT FROM ROTOR
CARBONIZER STEAM DESUPERHEATER
DEAERATOR
CONDENSER 2.5" HgA
CONDENSATE PUMP
WATER PUMP
SPRAY WATER PUMP
SPRAY PUMP
H/P BOILER FEED WATER
V58IG
COMP
EXPANDER
TURBINE COOLING AIR
INLET
AMBIENT AIR
HRSG
STACK
DRYER
AIR COOLER
CONDENSATE

Figure 1

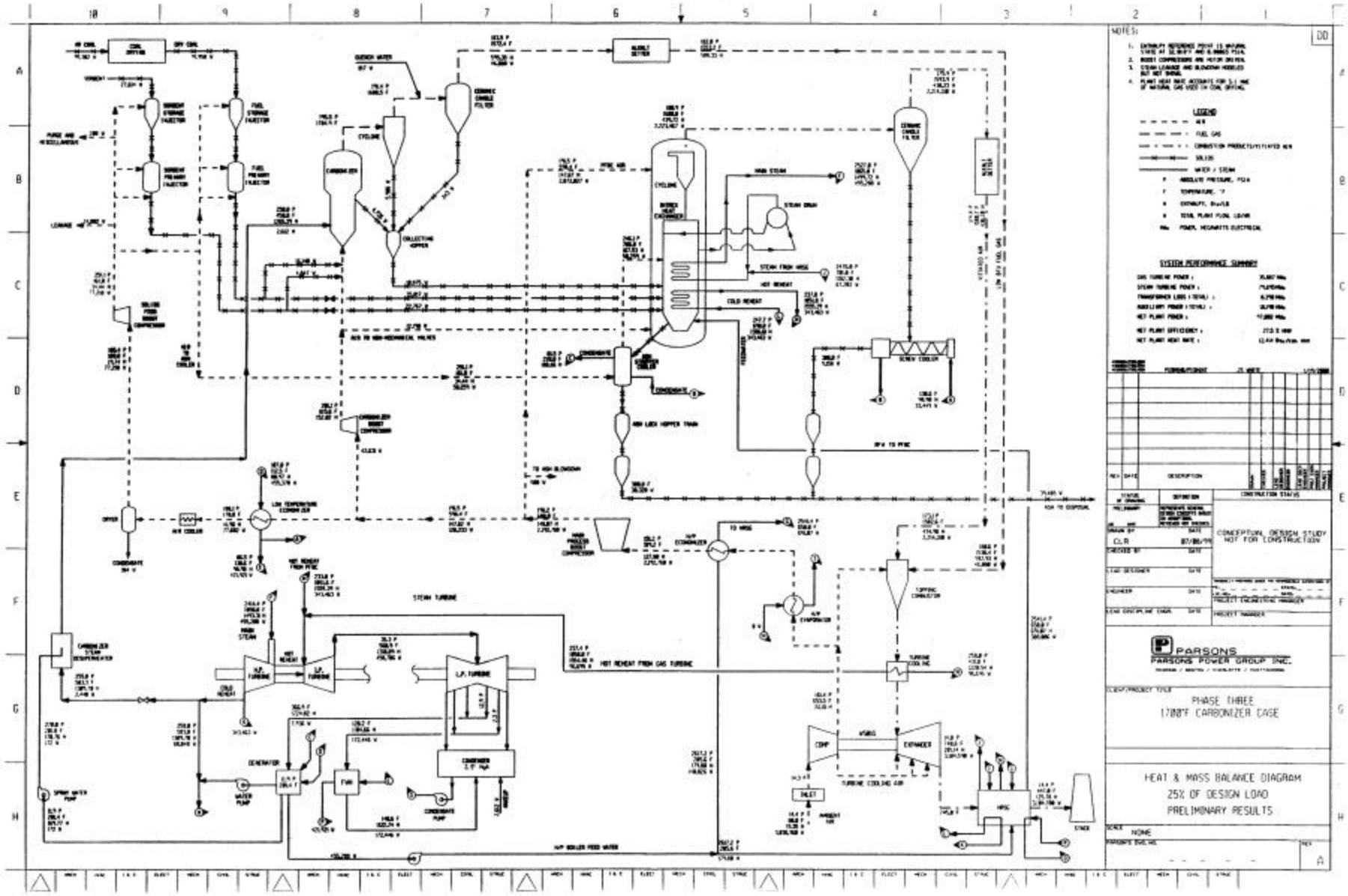
PARSONS
PARSONS POWER GROUP INC.
PHASE THREE
1700°F CARBONIZER CASE
HEAT & MASS BALANCE DIAGRAM
25% OF DESIGN LOAD
PRELIMINARY RESULTS
CONCEPTION, DESIGN STUDY
NOT FOR CONSTRUCTION
SYSTEM PERFORMANCE SUMMARY
LEGEND
NOTES:
STEAM TURBINE
HOT REHEAT FROM GAS TURBINE
HP BOILER FEED WATER

Figure 2

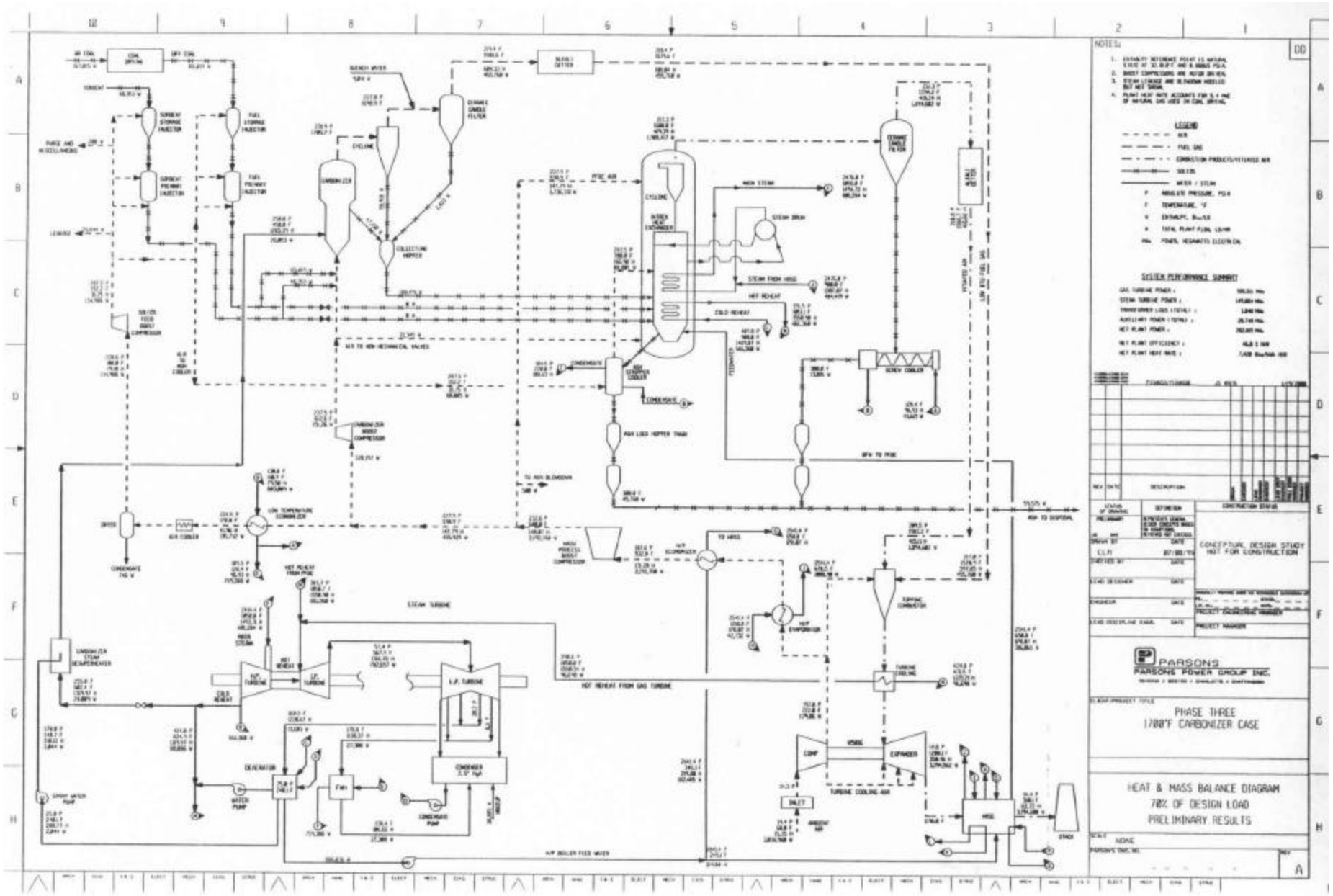
PHASE THREE
1700°F CARBONIZER CASE
HEAT & MASS BALANCE DIAGRAM
70% OF DESIGN LOAD
PRELIMINARY RESULTS
PARSONS
PARSONS POWER GROUP INC.
CONCEPTUAL DESIGN STUDY
NOT FOR CONSTRUCTION

Figure 3

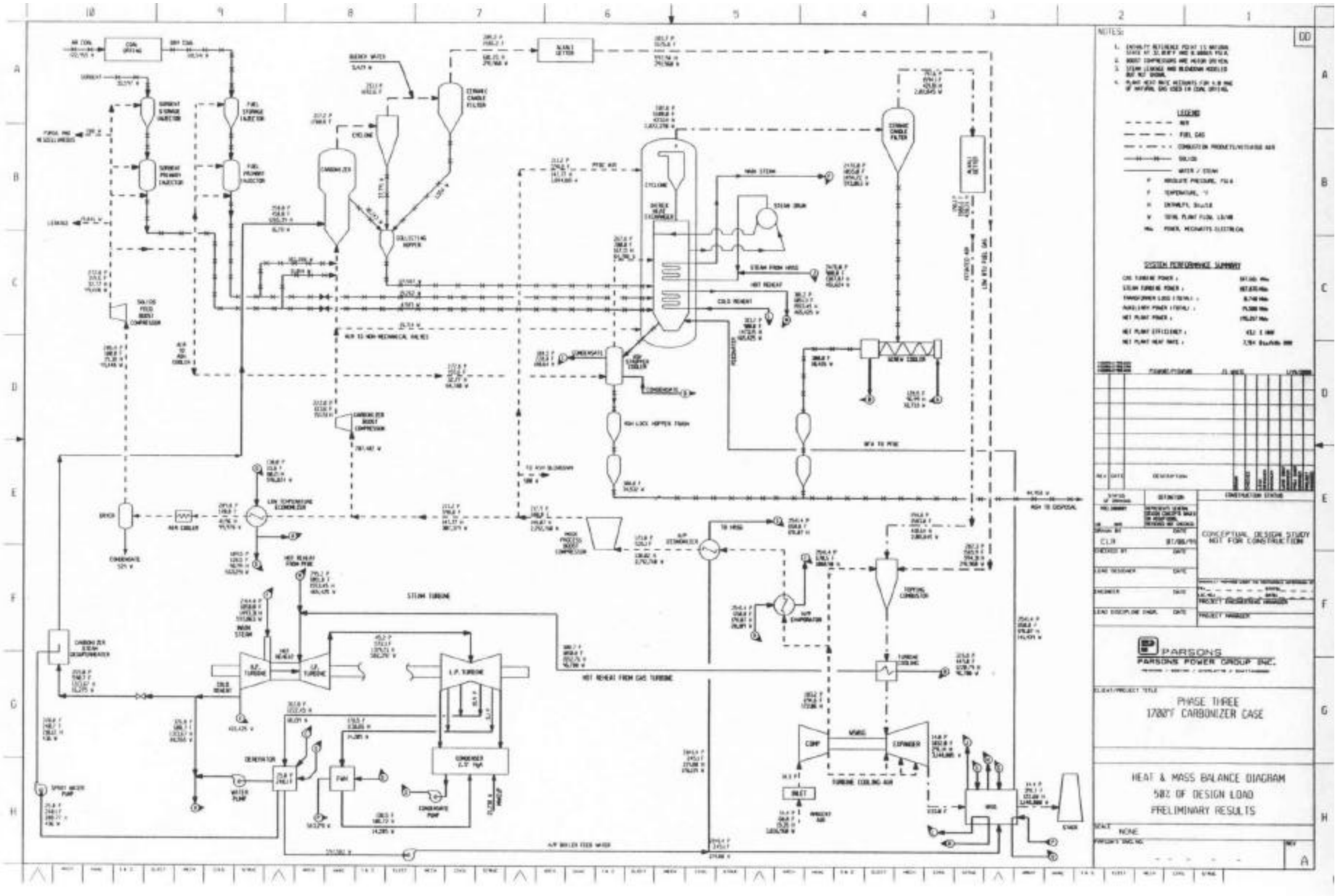
PARSONS
PARSONS POWER GROUP INC.
PHASE THREE
1702°F CARBONIZER CASE
HEAT & MASS BALANCE DIAGRAM
50% OF DESIGN LOAD
PRELIMINARY RESULTS
CONCEPTUAL DESIGN STUDY
NOT FOR CONSTRUCTION
STEAM TURBINE
HOT REHEAT FROM GAS TURBINE
CONDENSER
COMPRESSOR
EXPANDER

Figure 4